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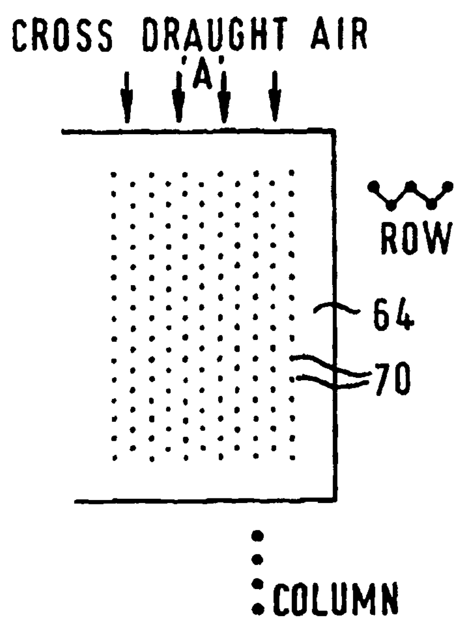
(54) Title: SPINNERETTE

(57) Abstract

A spinnerette (64) for the production of lyocell filaments, and intended for use in a spinning cell having a cross–draught (A), has jet holes (70) arranged in rows and columns, the columns extending in the direction of the cross–draught (A) and the rows extending transversely thereof. The cross–draught effect is maximised by the spinning holes in the columns being spaced a different distance apart, preferably further apart, than the spinning holes in the rows.



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Spinnerette

Field of the Invention

This invention relates to spinnerettes and spinning cells and has particular reference to spinnerettes and spinning cells suitable for the spinning of lyocell filaments from a solution of cellulose in a solvent, particularly a tertiary amine N-oxide.

Background of the Invention

As used herein, the term "lyocell" is defined in accordance with the definition agreed by the Bureau International pour la Standardisation de la Rayonne et de Fibres Synthetique (BISFA) namely:-

> "A cellulose fibre obtained by an organic solvent spinning process; it being understood that:-
>
> (1) an "organic solvent" means essentially a mixture of organic chemicals and water; and
>
> (2) "solvent spinning" means dissolving and spinning without the formation of a derivative".

Thus a lyocell fibre is produced by the direct dissolution of the cellulose in a water-containing organic solvent - typically N-methyl morpholine N-oxide - without the formation of an intermediate compound. After the solution is extruded (spun), the cellulose is coagulated as a fibre. This production process is different to that of other cellulosic fibres, such as viscose, in which the cellulose is first converted into an intermediate compound which is then dissolved in an inorganic "solvent". The solution in the viscose process is extruded and the intermediate compound is converted back into cellulose.

Description of the Related Art

US-A-4,416,698 (McCorsley), the contents of which are incorporated herein by way of reference, describes a method of producing cellulose filaments by dissolving the cellulose in a suitable solvent such as a tertiary amine N-oxide. One of the features of such a system is that the solution, commonly referred to as a dope, is both hot and, if it contains a significant quantity of cellulose, viscous, requiring the use of extrusion pressures in the range of from 15 bar to 200 bar. Such pressures are similar to those experienced in melt-spun polymers systems, such as polyester systems.

Having produced the solution of cellulose in the solvent, the solution is extruded or spun through a suitable die assembly including an unspecified jet to produce filamentary material which is passed into water to regenerate the cellulose by leaching out the amine oxide solvent from the extruded filaments.

The production of artificially formed filaments of material by extruding or spinning a solution or liquid through a spinnerette to form the filaments is, of course, well known. Initially, relatively small numbers of individual filaments were prepared, which filaments were individually wound up for use as continuous filament material. This meant that the number of continuous filaments which needed to be produced was essentially dictated by the number of filaments which could be individually wound either before or after drying.

However, if fibre is produced as a tow or if fibre is produced as staple fibre then different criteria apply to the number of filaments which can be produced at any one time. A tow essentially comprises a bundle of essentially parallel filaments which are not handled individually. Staple fibre essentially comprises a mass of short strands of fibre. Staple fibre can be produced by the cutting of

dry tow or it can be produced by forming a tow, cutting it whilst still wet, and drying the cut mass of staple fibre.

Because there is no need to handle individual filaments in the case of a tow product or a staple product, a very large number of strands or filaments can be produced simultaneously.

Thus in the case of spinnerettes for the production of tow or staple fibre, in comparison to spinnerettes used for the production of continuous filament material, it is economically essential to use spinnerettes with a large number of spinning holes. With spinnerettes used for the production of tow or staple fibre the number of holes can be into thousands or even tens of thousands. Productivity can thus be increased traditionally by the use of more holes as well as high speeds.

A known spinnerette is shown in our international patent specification WO94/28210.

After leaving the spinnerettes or jets, the extruded fibres pass into a spinning cell, first passing through an air gap and then passing into a coagulation or spin bath. This air gap is defined at the lower side by the surface of the spin bath and at the upper side by the spinnerette from which the extruded fibres or filaments emerge. It is known from our international patent specification WO94/28218 to provide a cross-draught across the air gap. This cross-draught is provided by a blow nozzle having an exit on one side of the air gap, and a suck nozzle having an entrance on the opposite side of the air gap to that of the blow nozzle.

The solution of cellulose in the organic solvent may be, and is preferably, passed through a jet assembly as described in our international patent specification WO94/28209, the contents of which are incorporated herein by way of reference.

In the production of lyocell, the constraints on the volume of fibre produced may frequently be set not by the capacity of the spinning process but by the capacity of the plant downstream of the spinning process. This capacity is frequently set by the maximum practical linear speed that the fibre can be transported through the plant. Therefore for a fibre plant capacity the spinning process can be optimised.

The production of jet holes is a very expensive and time consuming process. Each jet hole has to be pierced individually. Very often the jet holes are of a complex shape and are produced by a series of drilling, punching or machining operations.

With any production process there is a risk of defects and for a given percentage defect level, however low, the absolute number of defects per jet will increase as the number of holes in the jet increases.

The present invention seeks to provide a means of increasing the production for a given number of jet holes, or, by using fewer jet holes, to achieve a similar plant capacity. The invention particularly maximises the cooling effect of the cross-draught, and the removal of water vapour for stabilising the filaments.

Yet another aspect of the present invention aims to increase the production rate for a given plant speed by increasing the number of jet holes per unit area of jet.

Statements of Invention

According to the present invention there is provided a spinnerette for the production of lyocell filaments and which is intended for use in a spinning cell provided with means for producing a cross draught, the spinnerette having jet holes arranged in columns and rows, the columns extending generally in the direction of the cross-draught

and the rows extending generally transversely of the cross-draught, characterised in that the effect of the cross draught is maximised in at least one portion of the spinnerette by spacing the holes in the columns a different distance apart to the holes in the rows.

The term "rows" is intended to include zig-zag rows extending generally transversely or perpendicular to the columns and also covers concentrically arranged circular rows as may be used in an annular spinnerette. In the case of "circular" rows, the columns are substantially radially aligned and the cross-draught is directed either radially inwardly or radially outwardly relative to the common axis of the circular rows.

If the number of rows of filaments in the cross-draught direction (that is the number of holes in a column) is reduced, there is an increase in the cooling effect and a consequential increase in the maximum speed that fibres can be taken from the spinnerette. In at least said one portion the maximum number of holes per column should not exceed forty five (45) holes per column. In the preferred embodiment the number of jet holes per column should not exceed thirty nine (39) jet holes and, more preferably, should not exceed thirty (30) jet holes.

The spacing between the centres of adjacent holes in any one column should not exceed 2.0 mm and preferably should lie between 0.87 and 1.25 mm.

Preferably the spacing between adjacent columns is less than the spacing between adjacent rows. This results in the jet holes being arranged in a pattern in which they form isosceles triangles, with the base of each triangle being formed between two adjacent jet holes in a column.

The minimum distance between adjacent columns is about 0.4 mm, and preferably about 0.49 mm and the base

angles of isosceles triangles formed between the jet holes is less than 55° and preferably lies between 20-45°.

The present invention preferably relates to spinnerettes having preferably at least 3000 holes and up to 60,000 holes, preferably between 8,000-25,000 holes, and more preferably 8,000-13,000 holes, and more typically no more than 10,000 jet holes.

In a preferred arrangement, the columns of jet holes extending from the blow side to the suck side of the spinnerette contain no more than forty five holes.

Also according to the invention there is provided a spinning cell for the coagulation of lyocell filaments from a dope of cellulose containing an organic solvent for cellulose, including a spinnerette for the production of lyocell filaments, a spin bath for leaching solvent from the filaments which is spaced by an air gap from the spinnerette, and means for providing a cross-draught across the air gap and over the filaments, the spinnerette being of a type according to the present invention.

Where the jet holes are provided in a plurality of aperture plates held in a spinnerette body so that the columns and rows of jet holes are aligned, the number of jet holes in each column is the total number of aligned jet holes for the aligned aperture plates combining to form said columns.

The invention further provides a method of spinning lyocell filaments from a solution of cellulose in an amine oxide solvent, comprising forcing the cellulose solution through a spinnerette having jet holes therein to form filaments of lyocell through said jet holes, passing said filaments through an air gap into a spin bath to coagulate the filaments, and blowing a cross-draught of air across said air gap, the jet holes being arranged in columns and rows with the columns extending in the direction of the

cross-draught and with the rows extending transversely of the cross-draught, and in order to maximise the cooling effect and water vapour removal of the cross draught in at least one portion of the spinnerette, the spacing between the holes in the columns is different from, preferably greater than, the spacing between the holes in the rows.

Preferably, in said one portion there is a maximum of forty five jet holes in any column so that there is a maximum of forty five filaments in alignment in the direction of the cross-draught.

Description of Drawings

Embodiments of the invention will now be described, by way of example only, and with particular reference to the accompanying drawings, in which:-

Figure 1 is a cross-sectional view along a minor axis of a jet assembly;

Figure 2 is a perspective view of a spinnerette;

Figure 3 is a plan of the spinnerette shown in Figure 2;

Figure 4 is a cross-section taken on the line IV-IV of Figure 3;

Figure 5 is a plan of an individual aperture plate which is utilised in the spinnerette of Figure 3;

Figure 6 illustrates an example of one jet hole arrangement;

Figure 7 shows the relationship between columns and rows of jet holes and in particular in relation to the cross-draught direction;

Figures 8 to 10 show various alternative jet holes arrangements;

Figure 11 is a perspective view of the upper portion of a spinning cell;

Figure 12 is a graph of spinnerette productivity versus the number of rows in the jet arrangement; and

Figure 13 is a graph of percentage productivity calculated against a standard versus the number of rows in the jet arrangement.

Detailed Description of the Invention

Referring to Figure 1, this shows a jet assembly, of the type described in WO94/28209, located within an insulating cover 1 and frame 2. The frame 2 is thermally insulated from its steel support structure, and has a bore 3 extending around the frame through which a suitable heating medium such as hot water, steam, or oil, can be passed to heat the lower end of the frame. Because the cellulose solution spun through the jet assembly is supplied to the jet assembly at an elevated temperature, typically 100-110°C, it is preferable to provide heating to maintain the solution at the correct temperature and to provide insulation to minimise excessive heat loss and to prevent injury to operating personnel.

Bolted to the frame 2 by means of bolts or studs 4, 5 is a top housing 6. The top housing forms an upper distribution chamber 7 into which is directed an inlet feedpipe 8. The inlet feedpipe is provided with an O-ring seal 9 and a flange 10. A locking ring 11 is bolted to the upper face 12 of the top housing 6 to trap the flange 10 to hold the inlet feedpipe on the top housing. Suitable bolts or studs 13, 14 are provided to bolt the ring 11 to the top housing 6.

Bolted to the underside of the top housing 6 is a bottom housing 20. A series of bolts 21, 22 are used to bolt the top and bottom housing together and an annular spacer 23 forms a positive stop to locate the top and bottom housings together at a predefined distance.

The bottom housing 20 has an inwardly directed flange portion 24 which has an annular upwardly directed face 25. The upper housing 6 has an annular downwardly directed horizontal clamping face 26.

Clamped between the faces 25 and 26 is a spinnerette 60, a breaker plate 36 and a filter element 37. The spinnerette, shown in perspective view in Figure 2, essentially comprises a rectangular member in plan view, having a top hat cross section and comprising an upwardly directed peripheral wall 28 incorporating an integral outwardly directed flange 29. The spinnerette incorporates a plurality of aperture plates 64 which contain the holes through which the solution 33 of cellulose in amine oxide is spun or extruded to form the filaments 34.

Details of the spinnerette construction, including its materials, form of jet holes etc., are given in international patent specification WO94/28210, the contents of which are incorporated herein by way of reference.

Located on the upper surface of the flange 29 is a gasket 35. Located on top of the gasket 35 is the breaker plate 36 which essentially comprises an apertured plate used to support the filter element 37. The filter element 37 is formed of sintered metal, and if the sintered metal has a fine pore size, the pressure drop across the filter can, in use, deform the filter. The breaker plate 36, therefore, supports the filter in use. A pair of gaskets 38, 39 on either side of the filter element 37 completes the assembly located between the upwardly directed face 25 of the bottom housing and the downwardly directed face 26 of the top housing. By clamping the assembly together with the bolts

21, 22, the spinnerette, breaker plate and filter are held positively in position.

Located beneath the bottom housing 20 is a thermally insulating ring 40 which is generally rectangular in plan shape. The thermally insulating ring extends around the complete periphery of the wall 28, which wall 28 extends below the lower face 41 of the bottom housing 20. On one long side of the spinnerette, there is provided an integral extension portion 42 of the insulating ring 40 which extends below a long wall portion 43 of the peripheral wall 28. Beneath the other long wall portion 43A of the peripheral wall 28 the insulating ring 40 does not have the integral extension portion 42, but the lower face 44 of the ring 40 is in the same plane as the lower face 46 of the portion 43A of the peripheral wall 28 of the spinnerette.

The spinnerette 60 shown in Figures 2 to 4 is essentially of rectangular shape, as shown in Figure 3. The flange 29 may be provided with holes (not shown). Located within the wall 28 and integral therewith, or welded thereto, are a series of bracing walls 61, 62. The braced structure may in the case of an integral unit be machined from a single plate or thin slab. The bracing walls 61 are formed parallel to the major axis of the spinnerette and the bracing wall 62 lies transversely thereto along the minor axis of the spinnerette. The bracing walls form, together with the peripheral wall 28, a series of apertures or windows 63. The material from which the outer wall and braces of the spinnerette are formed is preferably stainless steel and is further preferably stainless steel in accordance with AISI code 304.

Welded into the bottom of the spinnerette are six aperture plates 64 which contain the actual holes through which the cellulose solution is extruded. The spinnerette 60 has an underside in a single plane and is capable of withstanding the high extrusion pressures experienced in spinning a hot cellulose solution in amine oxide.

The aperture plates 64 are substantially identical one with another and have a plurality of jet holes 70 formed therein (see Figure 7). Details of the shape of the jet holes, and their formation are given in WO 94/28210. Figure 6 discloses a typical prior art jet hole formation shown in WO 94/28210 in which the jet holes 70 are arranged at the corners of equilateral triangles with the bases of the triangles being parallel to one edge of the aperture plate. The jet holes typically have a diameter in the range of 25-150 microns depending upon the decitex of the fibre to be spun. More typically the jet holes diameter will be in the range of 50-120 microns.

After passage through the spinnerette 60, the extruded fibres are passed to a spinning cell, of the type disclosed in patent specification WO 94/28218, the contents of which are incorporated herein by way of reference, which has a cross-draught of air in the air gap to cool the filaments as they emerge from the spinnerette. Typically the temperature at which the cellulose solution is extruded through the spinnerette is in the range 95°C to 125°C. If the temperature drops too low, the viscosity of the cellulose solution becomes so high that it is impractical to extrude it through a spinnerette. Because of the potential exothermic nature of the cellulose solution in N-methyl morpholine N-oxide (hereafter referred to as NMMO), it is preferred that the temperature of the solution - sometimes referred to as a dope - is maintained below 125°C, preferably below 115-110°C. Thus, the temperature of the dope in the spinnerette is close to, at, or above, the boiling point of the water which is typically used in the spin bath. The contents of the spin bath may be water alone or a mixture of water and NMMO. Because the NMMO is continuously leached from the filaments into the spin bath, the spin bath would during normal operation always contain NMMO.

Referring to Figure 11, this shows schematically the upper end of the spinning cell which has an air gap and a

cross-draught arrangement. The spinning cell has a spin bath 115 with an upper surface 116 defined by edges 117, 118, 119 and 120 of the spinning cell. Effectively, the edges act as dams or weirs and a slight excess of spin bath liquor is passed into the cell to flow over the weirs so as to form a surface 116 of constant location and therefore of fixed height.

A cross-draught in the form of air having a temperature in the range 10°C to 40°C and a relative humidity in the range of dew points -10°C to +10°C is blown across the air gap in the direction of arrow A from a blow nozzle 121 into a suction nozzle 122. Air is sucked through the nozzle 122 so as to maintain a parallel flow of air across the spin bath. The thickness of the blow nozzle 121 is about one quarter to one fifth of the thickness of the suction nozzle 122. The lower edge 123 of the suction nozzle 122 is substantially at the same level as the edge 119 of the spin bath. The edge 123 may be slightly below the level of the spin bath edge 119. Air typically at 20°C is blown at 10 metres/second across the air gap.

Typically the blow nozzle 121 has a thickness of about 5 mm and the air gap would then be about 18 to 20 mm. The spinnerette produces filaments 125 which are passed through the spin bath 115 for coagulation.

The spinnerette 60 is arranged with its major axis transverse to the direction A of the cross-draught, that is transverse to air passing from blow nozzle 121 to suction nozzle 122. This is shown in Figure 3.

Now with reference to Figure 7, there is shown an aperture plate 64 with a plurality of jet holes 70 therein arranged in columns and rows. The columns extend in the direction of the cross-draught, substantially parallel thereto, and the rows are each of zig-zag form extending generally transversely to the cross-draught direction, i.e. generally perpendicular to the direction of the columns.

The present invention provides for particular jet arrangements with the jets being arranged in columns and rows, so as to provide for the optimum cooling effect of the cross-draught on the filaments emerging from the spinnerette.

A number of trials were carried out using prior art jet hole arrangements (shown in Figure 6) but with hole spacings as detailed using 15% cellulose, 80/20 LV/HV (that is, low molecular weight/high molecular weight) in NMMO/water solvent at a cross-draught velocity of 8 m/sec.

The jet arrangements and results of spinning the lyocell dope into 1.7 decitex (nominal tow) are shown in Table 1 and Table 2. The results are also shown graphically in Figures 12 and 13.

Table 1 and Figure 12 relate to the number of rows of holes (i.e. number of holes per column) versus jet productivity expressed as an index based on 100 equating to a specified arrangement of jets.

Table 2 and Figure 13 relate to the number of rows of holes versus jet productivity expressed as an index of 100, as before, for different hole arrangements in the jet plates.

TABLE 1

Description of spinnerette hole arrangement in each jet			Jet Productivity as Percentage of Prior Art Standard
Number of rows of holes	Row spacing (mm)	Column spacing (mm)	
60	0.88	0.76	70%
40	0.88	0.76	110%
20	0.88	0.76	175%
54	1.00	0.87	75%
36	1.00	0.87	130%
45	1.20	1.03	100%
30	1.20	1.03	150%
36	1.50	1.30	140%

TABLE 2

Description of spinnerette hole arrangement		Productivity as Percentage of Prior Art Standard
Number of rows of holes	Number of columns of holes (eg for 10,000 jet holes)	
50	200	~95%
45	222	100%
40	250	~105%
30	333	~110%
25	400	~120%

Performance of jets with same overall hole packaging density and total number of holes but with holes arranged in different ways

It is apparent that as the number of rows of jet holes (i.e. holes per column) exceeds 40-45 jet holes, the output per end starts to drop and the number of spinning cells needed to achieve a particular output at a particular decitex increases.

It is also apparent that there is some slight improvement in output as the column spacing is increased. As can be seen in Figure 12 the effect of minimising the number of rows of jets to 40 or less is more dominant than the effect of increasing the column spacing, and the optimum increase in production speeds is achieved by increasing the

number of jet holes whilst at the same time decreasing the number of jet holes per column and decreasing the spacing between columns. The preferred spacing between jet holes in each column should not exceed 2.0 mm and preferably should not exceed 1.5 mm and most preferably should lie between 0.87 mm and 1.25 mm. If the spacing between jet holes in each column is above 2 mm, other production problems begin to dominate.

For example a 13k spinnerette (i.e. a spinnerette having approximately 13 thousand jet holes), of the type with a 80 micron hole jet arrangement as shown in Figure 6, has 2175 holes formed in each of six respective plates of size approximately 19 mm x 164 mm, that is 150 columns of holes in 15/14 rows in each plate. These are arranged so that in the spinning cell there would be a maximum of 45 filaments in a column. The jet holes in each column are spaced by 1.2 mm and the columns are 1.039 mm apart. This is the reference jet arrangement defined as the index 100.

According to the present invention, to further optimise production, the jet arrangement could be altered to the arrangement shown in Figure 10 giving a 15k (approximately 15 thousand) jet-arrangement with 2518 holes per aperture plate arranged in 265 columns and 10/9 rows so that there are a maximum of 30 jet holes per column. The columns are spaced apart by 0.66 mm and the rows are spaced apart by 1.556 mm.

With reference to Figure 8, the hole arrangement shown therein would yield an aperture plate 17.5 mm x 190 mm having 245 columns x 13/12 rows = 3036 holes to give a jet assembly with 18378 holes. In this case there would be 39 rows spaced 1.05 mm apart, with the columns spaced 0.755 mm apart.

Yet another arrangement according to the present invention is shown in Figure 9 in which a 17.5 mm x 190 mm aperture plate has 341 columns in 11/10 rows to give a jet

assembly of 21486 holes. In this case the columns of jet holes are spaced apart by 0.544 mm, and the rows are spaced 1.25 mm apart.

It can be seen from Figures 8-10 that the jet holes are arranged in zig-zag rows which extend generally perpendicular to the direction of the columns. The jet holes form patterns of isosceles triangles, with the base of each isosceles triangle being located between adjacent holes in a column and the apex of the triangle being between the two base-defining holes in the adjacent column. The base angles of the isosceles triangles change in dependence upon the column spacing. In such an arrangement, the base angle is preferably less than 55° and more preferably is from 20°-45°.

Other arrangements of jet holes are possible according to the invention. The rows of jet holes may be straight instead of being of zig-zag form with the holes in each row and column being aligned. Indeed in the embodiments described herein a single zig-zag row of jet holes could be considered as being two adjacent lines of jet holes with the individual jet holes in each line off-set from each other. In this case, the spacing between the two "lines" of a zig-zag row is half the spacing between adjacent rows of jet holes. It is even possible for the "rows" of jet holes to be arranged in concentric circles with the "columns" being radially aligned.

The teaching in relation to reducing the number of jet holes in a column may also be applied to particular portions or areas of a spinnerette to improve filament cooling in these areas.

CLAIMS

1. A spinnerette for the production of lyocell filaments and intended for use in a spinning cell provided with means for producing a cross-draught, the spinnerette having jet holes arranged in columns and rows, the columns extending generally in the direction of the cross-draught and the rows extending transversely of the cross-draught, characterised in that the cooling effect of the cross draught is maximised in at least one portion of the spinnerette by spacing the holes in the columns a different distance apart to the holes in the rows.

2. A spinnerette as claimed in claim 1, wherein each row of jet holes has a zig-zag form with the jet holes arranged in two spaced apart lines, adjacent jet holes in each row being in different ones of said spaced apart lines.

3. A spinnerette as claimed in claim 2, wherein the spacing between the lines of each row of jet holes is half the spacing between adjacent zig-zag rows of jet holes.

4. A spinnerette as claimed in any one of claims 1 to 3, wherein the total number of jet holes in the jet assembly is between 8000 and 25,000, preferably between 18,000 and 22,000.

5. A spinnerette as claimed in any one of claims 1 to 4, wherein in at least said one portion of the spinnerette the maximum number of holes per column does not exceed forty five (45) holes in each column.

6. A spinnerette as claimed in any one of claims 1 to 5, wherein the jet holes in each column are spaced apart by a distance not exceeding 2.00 mm between centres.

7. A spinnerette as claimed in claim 6, wherein the distance between centres of jet holes in each column lies between 0.87 mm and 1.25 mm.

8. A spinnerette as claimed in any one of claims 1 to 7, wherein the jet holes across the whole spinnerette are arranged so that there are no more than forty five (45) holes in a column from the blow side to the suck side of the spinnerette.

9. A spinnerette as claimed in claims 8, wherein there are no more than thirty nine, preferably no more than thirty, jet holes in each column.

10. A spinnerette as claimed in any one of claims 1 to 9, wherein each jet hole has a diameter of from between 50 and 100 μm

11. A spinnerette as claimed in any one of claims 1 to 10, wherein the jet holes are provided in a plurality of aperture plates held in a spinnerette body so that the columns and rows of jet holes are aligned, and wherein the number of jet holes in each column is the total number of aligned jet holes for the aligned aperture plates combining to form said columns.

12. A jet assembly including a spinnerette as claimed in any one of claims 1 to 11.

13. A spinning cell for the coagulation of lyocell filaments from a dope of cellulose containing an organic solvent for cellulose, including a spinnerette for the production of lyocell filaments, a spin bath for leaching solvent from the filaments which is spaced by an air gap from the spinnerette, and means for providing a cross-draught across the air gap and over the filaments, wherein the spinnerette is of a type as claimed in any one of claims 1 to 11.

14. A method of spinning lyocell filaments from a solution of cellulose in an amine oxide solvent, comprising forcing the cellulose solution through a spinnerette having jet holes therein to form filaments of lyocell through said

jet holes, passing said filaments through an air gap into a spin bath to coagulate the filaments, and blowing a cross-draught of air across said air gap, the jet holes being arranged in columns and rows with the columns extending in the direction of the cross-draught and with the rows extending transversely of the cross-draught and in order to maximise the cooling effect of the cross draught in at least one portion of the spinnerette the spacings between the holes in the columns is different to the spacing between the holes in the rows.

15. A method as claimed in claim 14 wherein there is a maximum of forty five jet holes in any column so that there is a maximum of forty five filaments in alignment in the direction of the cross-draught.

16. A method as claimed in claim 15, wherein there are no more than thirty nine jet holes in each column so that there are no more than thirty nine filaments in alignment in the direction of the cross-draught.

17. A method as claimed in any one of claims 14 to 16, wherein the filaments in one column do not overlap with the filaments in another adjacent column.

18. A method as claimed in any one of claims 14 to 17, wherein the filaments in the cross-draught are evenly spaced in columns across the whole spinnerette from the blow side to the suck side thereof.

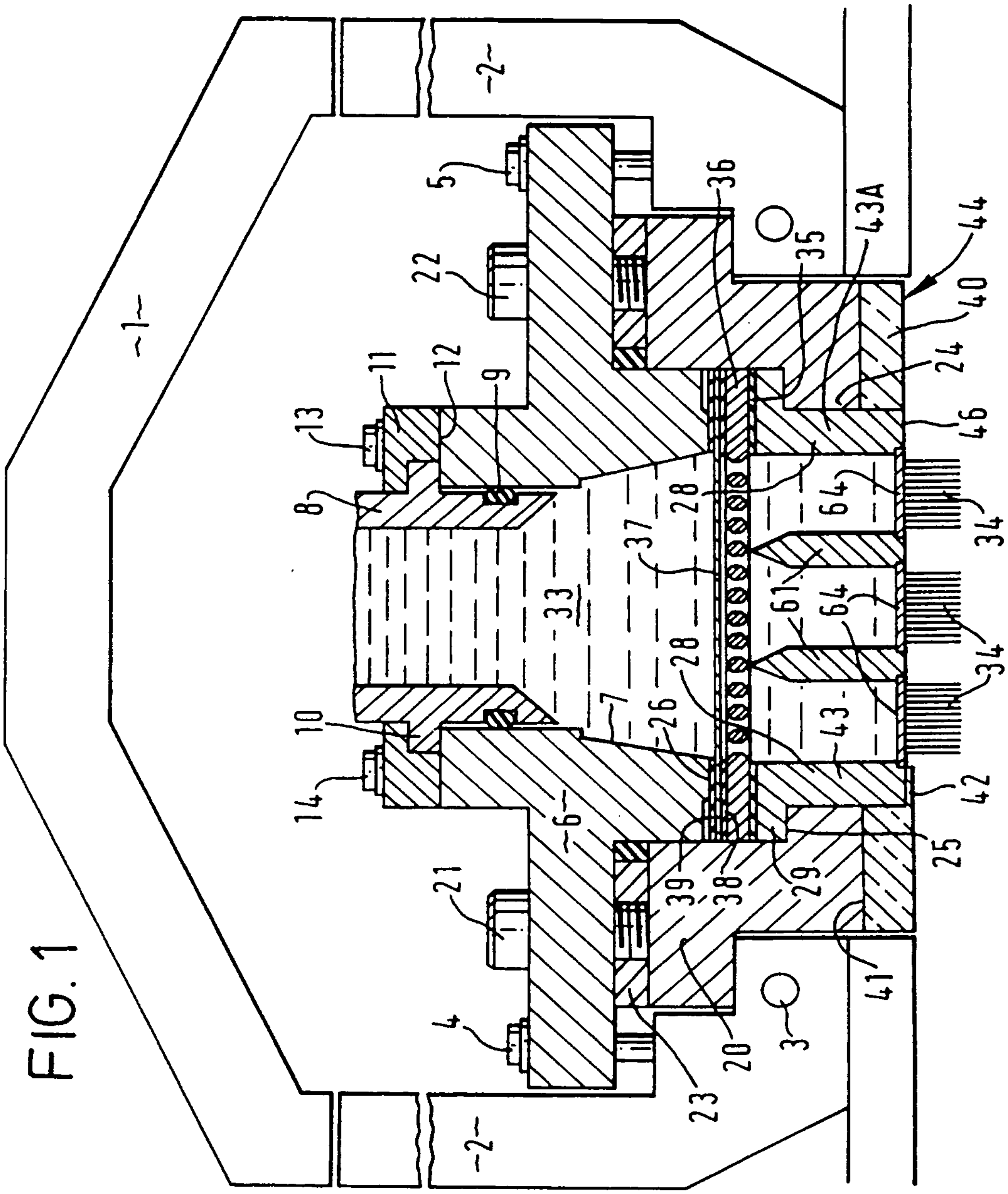
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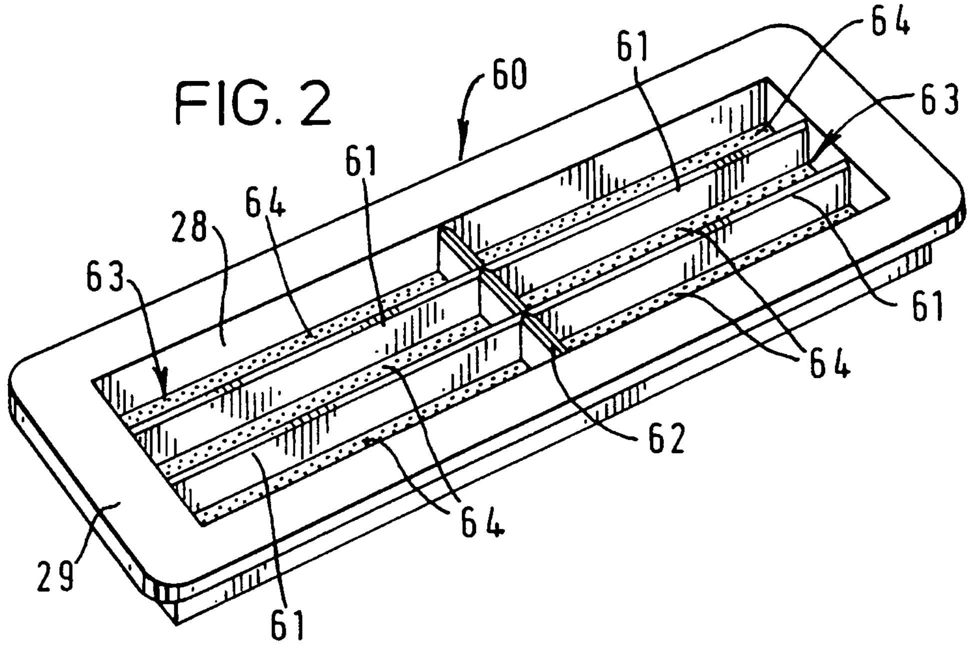
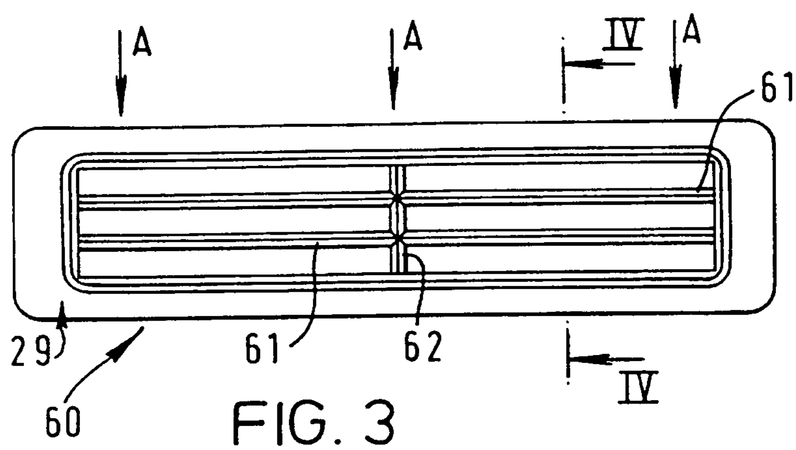
FIG. 1

FIG. 2





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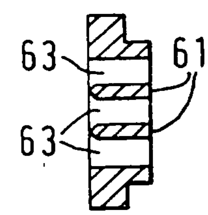

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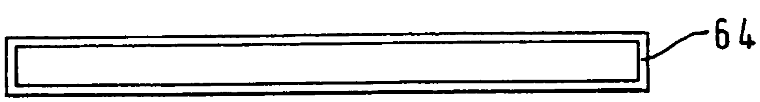

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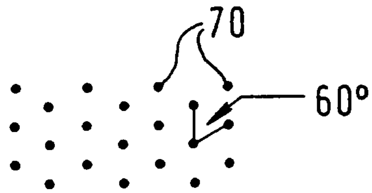

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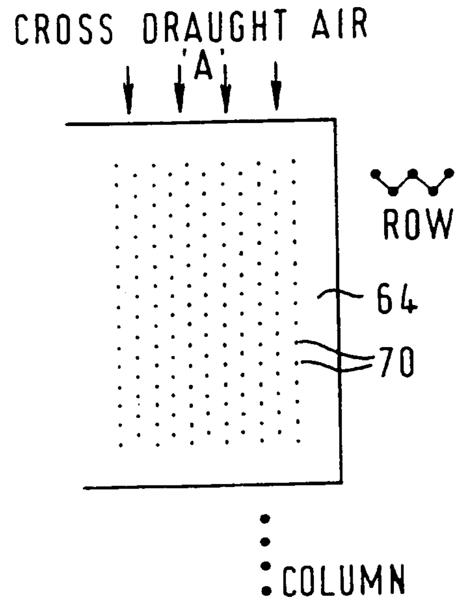
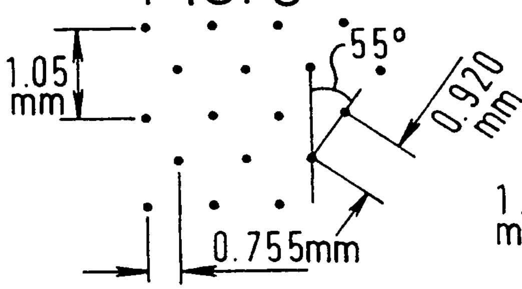


FIG. 7

FIG. 8



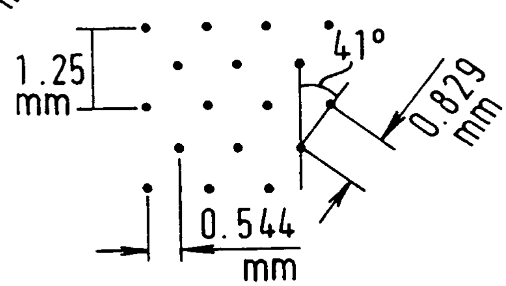


FIG. 9

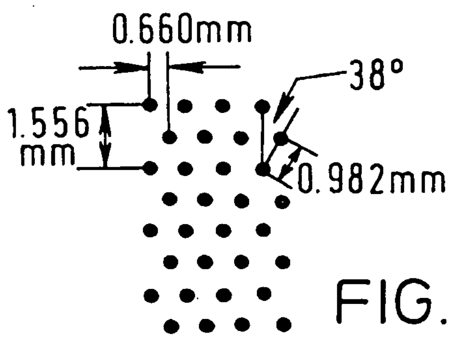


FIG. 10

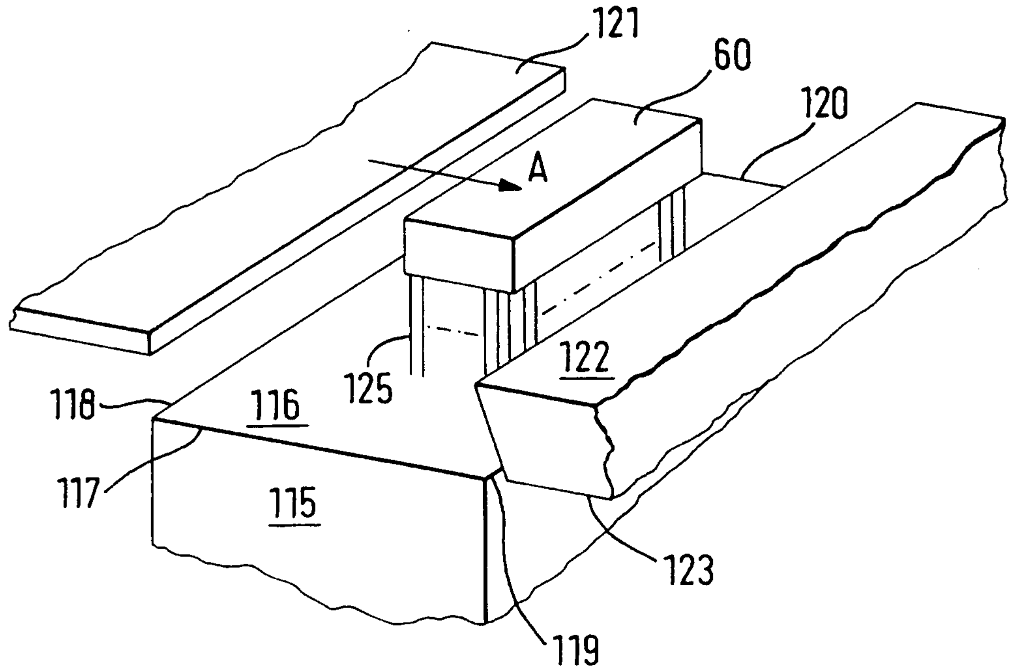
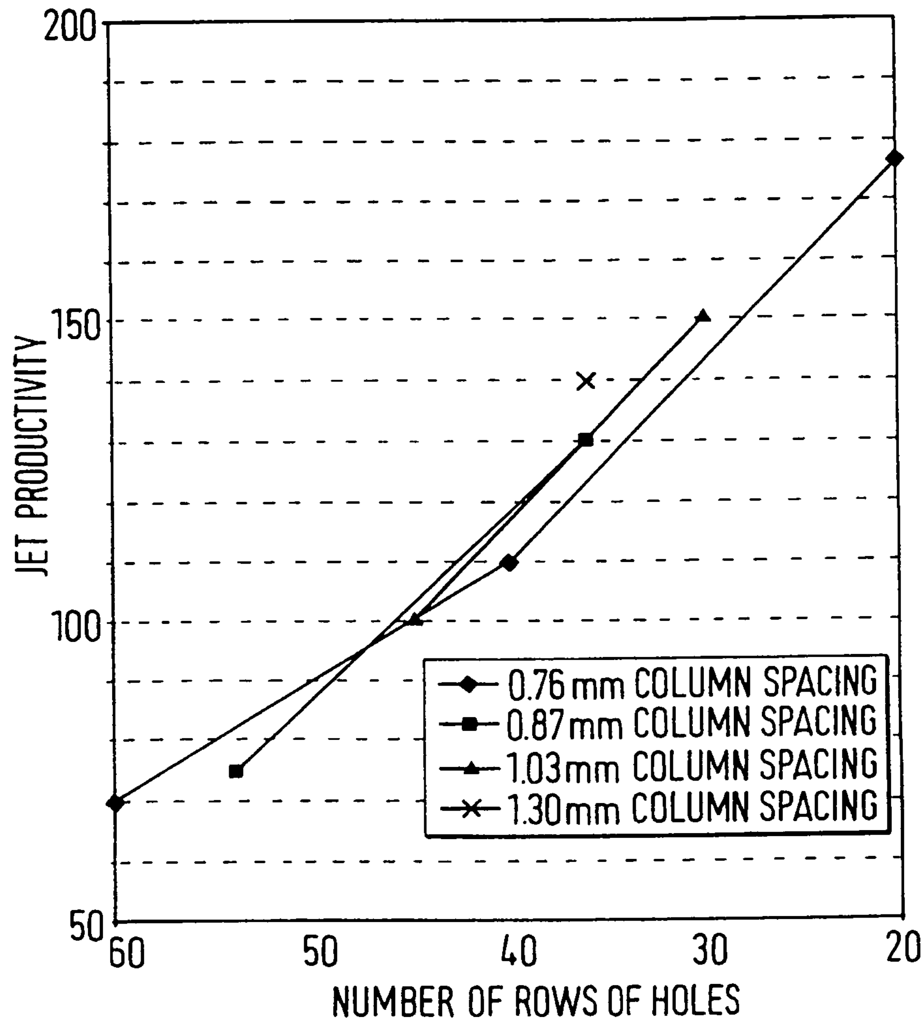


FIG. 11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20
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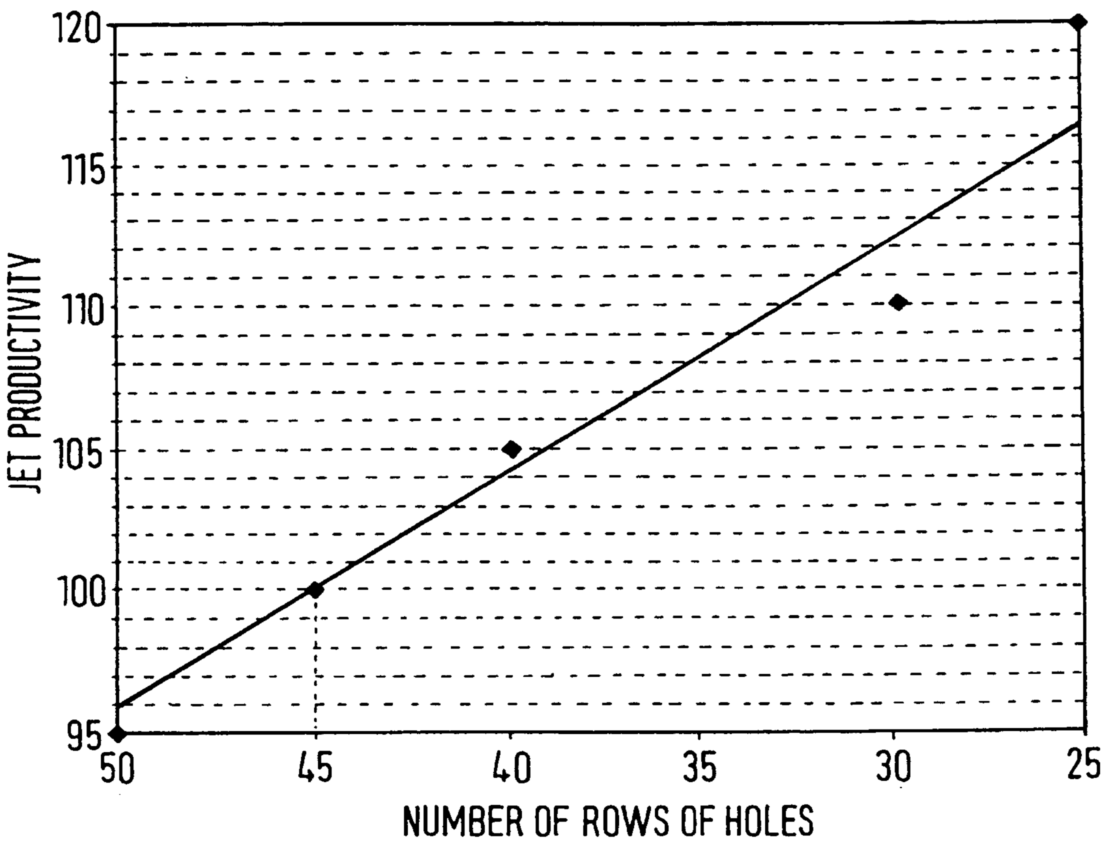
1.30 mm COLUMN SPACING

FIG. 12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35
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NUMBER OF ROWS OF HOLES

FIG. 13

INTERNATIONAL SEARCH REPORT

Inter ...al Application No
PCT/GB 97/02960

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 D01D4/02 D01F2/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 D01D D01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 94 28210 A (COURTAULDS FIBRES HOLDINGS LTD) 8 December 1994 cited in the application	1-11
Y	see the whole document ---	12-18
Y	WO 94 28209 A (COURTAULDS FIBRES HOLDINGS LTD) 8 December 1994 cited in the application see the whole document ---	12
Y	WO 94 28218 A (COURTAULDS FIBRES HOLDINGS LTD) 8 December 1994 cited in the application see the whole document ---	13-18

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

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Date of the actual completion of the international search	Date of mailing of the international search report
5 February 1998	18/02/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Tarrida Torrell, J

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INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/GB 97/02960

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 095, no. 008, 29 September 1995 & JP 07 126910 A (TORAY IND INC), 16 May 1995, see abstract	1-18
A	DD 140 400 A (WAGNER REINHARD;KEMNITZ WALTER; HENKEL HORST GUENTER; WEISS WENDELIN;) 5 March 1980 see the whole document	1-18

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INTERNATIONAL SEARCH REPORT

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International Application No
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 97/02960

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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DD 140400 A	05-03-80	NONE	

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